

Density and distribution of the Fish Eagle *Haliaeetus vocifer* on Lakes Naivasha and Ololdien, Kenya

Andrew C. Smart

The African Fish Eagle, *Haliaeetus vocifer* (Daudin), has been studied in the past at Lake Naivasha, with surveys in 1968–1973 (Brown & Hopcraft 1973), 1979 (Cambridge University Expedition 1979) and 1986 (Reading University Expedition 1986). This short study, carried out in July and August 1987 had three aims:

- a. To determine the current distribution of the birds around the lake.
- b. To consider whether a drop in lake level and recent changes in aquatic vegetation had altered the density or distribution of birds.
- c. To investigate the North Swamp, an area where high concentrations of juveniles were recorded by Brown & Hopcraft (1973) and Reading University Expedition (1986), and to determine whether juveniles were present in greater densities than elsewhere on the lake.

Study area

Lake Naivasha (0°45'S, 36°20'E) is freshwater and lies in the Kenyan Rift Valley at an altitude of 1890 m above sea level (Harper 1984). Lake Naivasha and the adjacent (slightly saline) lake, Ololdien are affected by rapid and frequent lake level fluctuations. Both lakes formed in extinct volcanic craters, and to the southwest lies a smaller crater, Sonachi, which contains an alkaline crater lake.

At Naivasha the natural vegetation is a successional sequence from aquatic macrophytes and papyrus (*Cyperus papyrus* L.), through *Cassia* and *Tarchonanthus* scrub to *Acacia* woodland (Gaudet 1977). The lake level at Naivasha was dropping at the time of this study. Between July and September, the lake level fell approximately 1 m in depth, continuing a trend that had been taking place since 1982 (Åse 1987). This drop in lake level resulted in a loss of much of the aquatic macrophytes, and a change from clear water lagoons and floating papyrus of the 1970s to turbid open water fringing papyrus. Introduced *Salvinia molesta* Mitchell is found around all the shore of Lake Naivasha, and is particularly abundant in the North Swamp and against the fringing papyrus along the east shore (Fig. 1). An increase in the extent of agriculture around the lake shore, particularly in the north and south west of the lake was causing the shoreline habitat to change at the time of this study. The lake at Sonachi Crater has no fish and is surrounded with dense *Acacia* woodland.

Lake Naivasha has been developed as a fishery and contains various introduced fish species—tilapia, (*Tilapia zillii* Gervais, and *Oreochromis leucostictus* Trewavas), and large mouth bass, (*Micropterus salmoides* Lacépède), all of which were observed taken by *H. vocifer* during this study.

Methods

A census of the eagle population was undertaken by three boat surveys of both lakes. Adult *H. vocifer* are territorial and remain within their territories for 80–90 per cent of the day (Brown & Hopcraft 1973), decreasing the possibility of double counting the

same birds. The lake shore was divided into 15 sections (Fig. 1), each section being approximately 5 km of shoreline, apart from Crescent Island (10 km) and Oloidien (10 km). Each survey involved a complete circuit of both lakes over three and a half days. The survey of Lake Naivasha was carried out between 10:00 and 16:00 hrs and completed in three days, the census route commencing where the previous day had ended. The census of Oloidien Lake took place between 10:00 and 13:00 hrs on the final day of the survey.

The location of birds along the shoreline and the dominant vegetation type were recorded on maps of the area during each survey. Stationary birds or birds which took flight and flew behind the boat as it moved towards them were recorded. Birds taking flight were only recorded if they flew behind the boat so as to minimize the risk of double counting. Areas with a high density of *H. vocifer* (Oloidien Lake, Crescent Island and Oloidien Bay, Fig. 1) were also surveyed from the shore to confirm the values found from the boat survey, though only values from the boat survey were used in any analysis.

Brown & Hopcraft (1973) refer to the different plumage types for first and second year birds, sub-adults and adults. In this study, birds were defined as either 'adult' or 'juvenile'. The definition of 'juvenile' used included first and second year birds, while 'adults' included any sub-adults which were present. Sub-adults can be included with adults when estimating the number of territory-holding pairs, since sub-adults and adults will pair and hold territories around the lake, the sub-adult losing its place in the pair if an adult bird becomes available (Brown & Hopcraft 1973).

Two trips were made to the North Swamp (The area north of the North swamp shoreline section, Fig. 1), much of which was under agriculture, and the area around the Malewa River, (north of the Malewa Input shoreline section, Fig. 1) to determine whether juvenile birds were present in these areas some distance from the lake shore.

Results

Table 1 shows the numbers and locations of fish eagles recorded on each survey. Compilation of the results from three surveys produced an estimate of 82 territory-holding pairs on both Naivasha and Oloidien (Fig. 1). The territory-holding population on each lake was estimated as: Lake Naivasha—68 pairs; Oloidien—13 pairs; Sonachi—1 pair. The mean number of *H. vocifer* in each shoreline section was used to calculate the density per kilometre of shoreline of both the adult and juvenile population. Density was compared with the dominant vegetation type (Table 2, Fig. 2). A comparison of the density per km of shoreline of both adult and juvenile *H. vocifer* around the lake on a site by site basis over the three surveys produced a value of Kendall's Coefficient of Concordance, W , indicating that the three surveys produced significantly similar results (adult *H. vocifer*: $W = 0.657$, $\chi^2 = 27.59$, d.f. = 14, $P \leq 0.05$; juvenile *H. vocifer*: $W = 0.579$, $\chi^2 = 24.32$, d.f. = 14, $P \leq 0.05$).

A Kruskal-Wallis test was applied to data values for each site from all three surveys, comparing the seven vegetation types with the values for density per km lake shoreline. This indicated that a significant difference exists between density of *H. vocifer* in different vegetation zones for both adult birds ($H = 19.99$, d.f. = 6, $P \leq 0.01$) and juvenile birds ($H = 19.99$, d.f. = 6, $P < 0.01$) as defined by this study. Differences between densities in different vegetation types were determined by comparing all vegetation types using a Mann-Whitney test and significant differences are shown in Table 3.

The percentage of juveniles in the population was found to be 6.2 per cent (mean value from three surveys). Previous values for juvenile percentage of the population

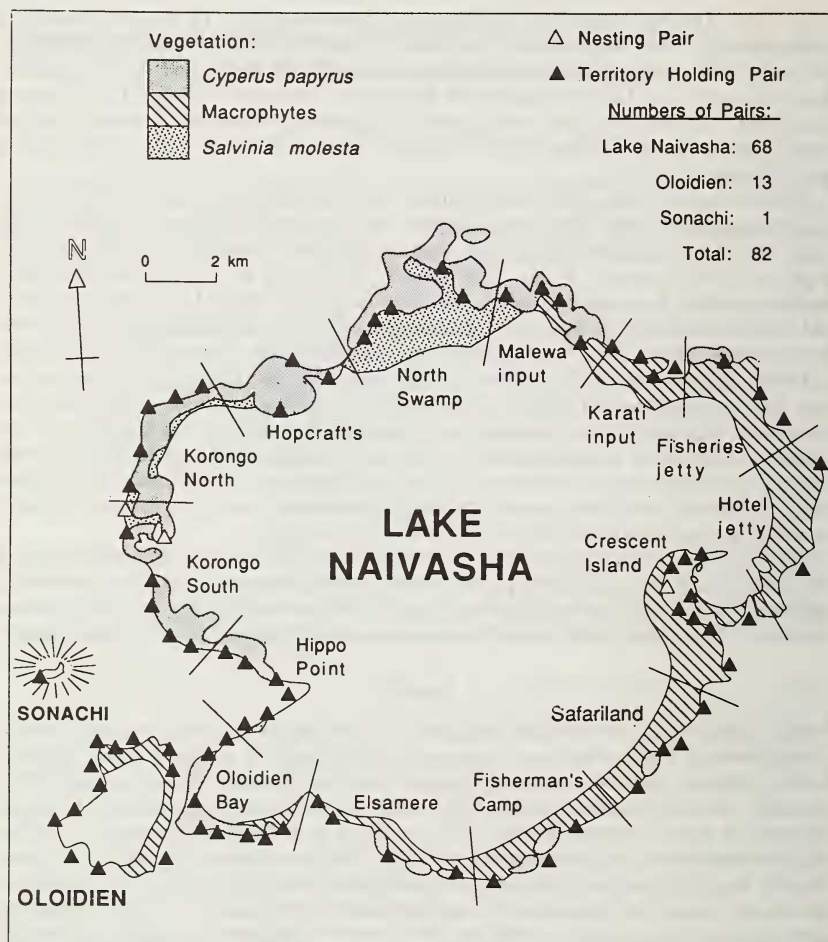


Fig. 1. Map of Lake Naivasha, Kenya, showing position of territory-holding and nesting pairs of Fish Eagle *Haliaeetus vocifer* and vegetation zones

were 15.6 per cent (Brown & Hopcraft 1973), 19.5 per cent (Cambridge University Expedition 1979) and 5.6 per cent (Reading University Expedition 1986). Three territories contained birds sitting on nests and one a nest with a juvenile. Two visits to the area of land now cleared and used for agriculture at the North Swamp produced no records of juvenile birds, though a number were seen in flight on one visit. Juveniles (3), one sub-adult and a pair of adults were located to the west of the Malewa River (North of the Malewa Input lakeshore section, Fig. 1). Investigation on the eastern side of the Malewa

Table 1. *Numbers of H.vocifer at Lake Naivasha, Kenya during three surveys in July and August 1987*

Lake section (5 km)	29 July –1 Aug.		14–18 August		28–31 August	
	Adult	Juvenile	Adult	Juvenile	Adult	Juvenile
Hotel jetty	4	2	4	0	3	0
Fisheries' jetty	7	0	5	0	7	0
Karati input	5	0	8	0	8	0
Malewa input	4	0	8	0	2	5
North Swamp	8	4	9	4	7	1
Hopcraft's	8	1	15	0	5	1
Korongo north	9	0	13	0	13	0
Korongo south	9	0	8	0	9	0
Hippo Point	9	1	13	0	9	0
Oloidien Bay	6	0	13	1	6	0
Elsamere	10	0	9	0	7	0
Fisherman's Camp	6	0	11	0	12	0
Safariland	6	0	4	0	7	0
Crescent Island (10 km)	15	1	21	1	21	3
Naivasha Total:	106	9	141	6	116	10
Oloidien (10 km)	27	2	27	1	21	0
Sonachi	2	0	2	0	2	1
Total:	135	11	170	7	139	11
	146		177		150	

was not undertaken because the area was unsafe to survey on foot, but the habitat was similar and would be expected to support some birds.

Records of the commercial catch on Lake Naivasha registered with the Kenyan Fisheries Department do not accurately represent the status of the fishery at any point in time because of changing mesh sizes and unknown levels of poaching. Official records do not exist for Oloidien Lake where poaching is minimal, but data from research carried out at Oloidien during 1986 and 1987 indicated fish numbers at Oloidien were increasing (S.M.Muchiri, unpublished data).

Discussion

H.vocifer numbers at Lake Naivasha had not altered from the previous year (Reading University 1986) with survey values of 115, 147, 126, compared with 144 in 1986. The estimated value of 68 pairs on Lake Naivasha compares with the 1968–1973 values for July–September of 114–172 individuals produced by Brown & Hopcraft (1973) and indicates that the birds were at similar densities at the same time of year in 1987. Brown & Hopcraft (1973) found numbers fluctuated with time of year even though birds breed throughout the year around the lake. The location of 51 pairs recorded by the Cambridge

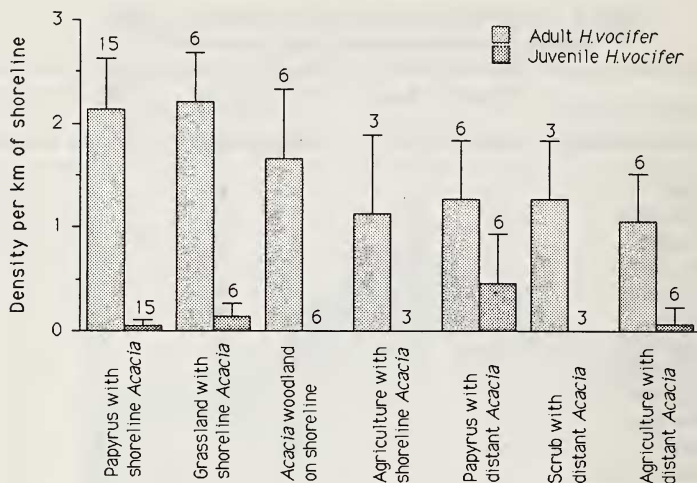


Fig. 2. Variation in density of *H. vocifer* adults and juveniles per km of shoreline habitat in different vegetation types at Lake Naivasha, Kenya showing 95 per cent confidence limits

Expedition on Lake Naivasha in 1979 suggested that no birds were holding territories between Fisheries' Jetty and Hopcraft's (Fig. 1), where a large area of papyrus reef (*Cyperus papyrus*) extended into the lake (I. Johnson, pers. comm.). This papyrus reef is no longer present and this stretch of shoreline, now fringed with papyrus and salvinia, supported an estimated 15 territory-holding pairs during 1987. The number of territories around the remainder of the lake has hardly altered; 51 pairs in 1979 and 53 pairs in 1987. The increase in territory-holding pairs of birds around Lake Naivasha between 1979 and 1987 may be associated with the change in habitat along the north lake shore. This may be an increase in preferred habitat, enabling more pairs to establish territories. Alternatively, the loss of the papyrus reef may enhance the ability of boat surveys to census territory-holding pairs. If the latter is true, it would suggest no 'real' increase in numbers since 1979.

The distribution of adult *H. vocifer* around the lake relative to habitats (Tables 2 and 3, Fig. 2) indicate that papyrus fringe with shoreline *Acacia* and grassland and shoreline *Acacia* have significantly higher adult densities than other vegetation types and that *Acacia* woodland is also important. The current loss of fringing papyrus for agriculture may lead to problems in the future if this small sample is representative of the density of birds expected in such a habitat. Other vegetation types are not significantly different from each other suggesting that the presence of shoreline *Acacia* is important in habitats other than agricultural land. Brown (1980) suggests that the population around Naivasha is not restricted by lack of breeding sites, with pairs taking up territories as non-breeders. It may be that the presence of perches at the lake shore within territories is an important factor in determining density of birds. Juvenile densities are significantly higher in areas with grassland and shoreline *Acacia* and in areas with papyrus and dis-

Table 2. *Density of H.vocifer per km of lake margin relative to vegetation on shoreline at Lake Naivasha, Kenya July–August 1987*

Main vegetation type (see Fig. 1)	Lake section	Density of <i>H.vocifer</i> per km shoreline					
		29 Jul–1 Aug		14–18 Aug		28–31 Aug	
		Ad	juv.	Ad	juv.	Ad	juv
Grassland with shoreline <i>Acacia</i>	Oloidien	2.7	0.2	2.7	0.1	2.1	0
	Crescent Island	1.5	0.2	2.1	0.1	2.1	0.3
Papyrus with shoreline <i>Acacia</i>	Korongo north	1.8	0	2.6	0	2.6	0
	Hopcrafts	1.6	0.2	3	0	1	0.2
	Hippo Point	1.8	0.2	2.6	0	1.8	0
	Oloidien Bay	1.2	0	2.6	0.2	1.2	0
	Korongo south	1.8	0	1.6	0	1.8	0
<i>Acacia</i> woodland on shoreline	Fisherman's Camp	1.2	0	2.2	0	2.4	0
	Elsamere	2	0	1.8	0	1.4	0
Agriculture with shoreline <i>Acacia</i>	Safariland	1.2	0	0.8	0	1.4	0
Papyrus with distant <i>Acacia</i>	North Swamp	1.6	0.8	1.8	0.8	1.6	0.2
	Malewa input	0.8	0	1.6	0	0.4	1
Scrub with distant <i>Acacia</i>	Fisheries' jetty	1.4	0	1	0	1.4	0
Agriculture with distant <i>Acacia</i>	Karati input	1	0	1.6	0	1.6	0
	Hotel jetty	0.8	0.4	0.8	0	0.6	0

tant *Acacia* (Table 3b). The high density of juveniles in grassland and shoreline *Acacia* habitat (Crescent Island and Oloidien) may be a result of particularly high concentrations of adult eagles in these areas. The high density of juveniles in areas with papyrus and distant *Acacia* coupled with the recording of birds in habitat away from the lake shore underlines the continued importance of the North Swamp and the area around the input of the Malewa River for juvenile *H.vocifer*.

The difference in habitat preference for juveniles, in particular the high numbers in areas with papyrus and distant *Acacia*, is of interest and warrants further study of interactions between adult and juvenile birds. The numbers of juveniles recorded during this study was low and as such no real indication of competition could be concluded.

H.vocifer density at Oloidien showed an increase, with 13 pairs in 1987 compared to 8 pairs recorded in 1979 (I. Johnson, pers. comm.). The fish population at Oloidien was higher than previous years during 1987, (S.M. Muchiri, pers. comm.) and a large number of flamingos *Phoenicopteridae*, preyed by *H.vocifer*, were present. The increase in territory-holding *H.vocifer* at Oloidien may be related to prey density. The pair at Sonachi (Crater Lake) also prey on the flamingos present at this saline lake which

Table 3. Significant differences between density of adult and juvenile *H. vocifer* in different habitat types from Mann-Whitney *U* tests between habitats

Adult		AS	SD	AD	AW	PD	PS
GS	**	**	**	NS	**	NS	
PS	*	*	**	NS	*		
PD	NS	NS	NS	NS			
AW	*	NS	NS				
AD	NS	NS					
SD	NS						
Juvenile		AS	SD	AD	AW	PD	PS
GS	*	*	*	**	NS	*	
PS	NS	NS	NS	NS	*		
PD	*	*	*	*			
AW	-	-	NS				
AD	NS	NS					
SD	-						

Key: AS: agriculture with *Acacia* on shoreline; SD: scrub with distant *Acacia*; AD: agriculture with distant *Acacia*; AW: *Acacia* woodland on shoreline; PD: papyrus with distant *Acacia*; PS: papyrus with shoreline *Acacia*; GS: grassland with shoreline *Acacia*

contains no fish. The apparent constancy of numbers of *H. vocifer* during the recent period of falling water level at Naivasha suggests that the population has been able to cope with changes in aquatic vegetation and the fluctuations of the fishery. The present removal of much of the fringing papyrus and the clearance of the North Swamp may have a more damaging effect on numbers, and monitoring should be continued in the future.

Acknowledgements

This work was carried out by the University of Leicester Lake Naivasha Project (Research Permit No. OP.13/001/12C 46), issued by the Office of the President of the Republic of Kenya. The author would like to thank the Kenya Government; the numerous organizations who funded the project; and the volunteers who helped during the surveys. Full acknowledgements are listed in the final report of the University of Leicester, Lake Naivasha Vertebrate Survey 1987. Thanks also to Dr I. Johnson for information regarding the 1979 and 1986 surveys, Mr S.M. Muchiri of the Kenyan Fisheries Department and colleagues at Leicester, particularly Mr I.P.F. Owens, and two anonymous reviewers for their comments on the manuscript.

References

- BROWN, L.H. 1980. *The African Fish Eagle*. Folkestone: Bailey Bros. and Swinfen Ltd.
- BROWN, L.H. & HOPCRAFT, J.B.D. 1973. Population structure and dynamics in the African Fish Eagle *Haliaeetus vocifer* (Daudin) at Lake Naivasha, Kenya. *East African Wildlife Journal* 11: 255–269.
- GAUDET, J.J. 1977. Natural drawdown on Lake Naivasha, Kenya, and the formation of papyrus swamps. *Aquatic Botany*. 3: 1–47.
- HARPER, D. 1984. Recent changes in the ecology of Lake Naivasha, Kenya. *Internationale Vereinigung für Theoretische und Angewandte Limnologie* 22: 1193–1197.
- UNIVERSITY OF CAMBRIDGE EXPEDITION 1979. *University of Cambridge Kenyan Eagle Study Expedition of 1979*. (Unpublished report). [Not seen, cited in: University of Reading Expedition 1986.]
- UNIVERSITY OF READING EXPEDITION 1986. *Report of the Reading University Kenyan Eagle Survey*. (Unpublished report.) Available at Royal Geographical Society.
- ÅSE, L-E. 1987. A note on the water budget of Lake Naivasha, Kenya. *Geografiska Annaler* 69 Ser. A: 415–429.

Dr Andrew C. Smart, The Durrell Institute of Conservation and Ecology, The University, Canterbury, Kent CT2 7NX, England

Scopus 14: 76–83, May 1991

Received 25 June 1990

Request for information

We are preparing an atlas of the breeding birds of Madagascar. This project will be based on surveys of museum collections, relevant literature, unpublished observations, and investigations of poorly known areas. The end product will be a comprehensive atlas of the distribution of Madagascar birds.

We are requesting information on holdings of Madagascar birds in small museums and private collections. We would also appreciate receiving unpublished notes, observations, or other suitable material on the birds of Madagascar. Contributions will be fully acknowledged. Steven M. Goodman and Thomas S. Schulenberg, Field Museum of Natural History, Roosevelt Road at Lake Shore Drive, Chicago, Illinois 60605, USA, (telephone (312) 922-9410); Olivier Langrand and Lucienne Wilmé, WWF Aires Protégées, B.P. 738, Antananarivo (101), Madagascar.

Please address all communications to Goodman and Schulenberg.

Correction

In the paper on Indian House Crows *Corvus splendens* by Dr Colin Ryall (*Scopus* 14: 14–16), the first sentence of the penultimate paragraph on p. 14 should read:

The first nest collection of 18 November 1985 at Makadara Park, a small paved park in the Mombasa town centre, and the second on 1 November 1985 at Mzimle, a large area of grassy parkland with numerous trees in the less crowded periphery of Mombasa Island.